fluctuations in the flow field is identified. These observations are important in understanding the response of a flame anchored in a backward-facing-step flow to acoustic-like external perturbations, as in situations of combustion instability.

T-3C-2. APPLICATION OF GATES ON A SETTING DAM AT THE ENTRANCE OF A CANAL

M. AKHYANI, *Department of Marine Science, Science and Research Branch, Islamic Azad University, Tehran, Iran*, S. M. MOSADDAD, *Islamic Azad University, Shoushtar Branch, Iran,* This is an empirical study to justification an ancient river engineering structure with its effect on its neighborhood. When river pass through a city, its effect on land will be more noticeable especially for agricultural and living processes around river basin. Building a setting dam on river gate, necessary water body will be conducted to river route and risk of flood or coastal destruction and erosion in banks of river would sweep away. Number and position of gates appointed on dam is very important hydraulically and hydro dynamically. In Shoushtar, a city lies beside one the major rivers of Iran, called “Karoon” River, “Band Mizzan” is a setting dam and divides Karoon water into two branches, called “Gar_Gar” and “Shotteit” with portion of water bodies in the ratio of 2 to 4 , the gates on it applies well and hydraulically existence of them has been very useful. Existence of setting dam will lead to water storage and flood prevention. The number of gates and their position in “Band Mizzan” were well appointed at hundreds years ago. Some useful and applied results of this study is: Setting dam should be establish perpendicular to river currents direction. Building of setting dam and establishing of the second canal in place of maximum curvature of river is an applied task to decrease the rate of sedimentation and bank erosion. Fastening of bank line of river, building of river coastal walls and deepening of the river basin would be useful to avoid happening of flood around of river. Flood currents and sedimentation in the river with high current velocity could be controlled by setting dam creation. Superposition of surface waves and secondary current wavelengths with dam structure mouths can lead to decrease erosion and make a calm River.

T-3C-3. SEPARATED-LAYER INSTABILITY AND GLOBAL UNSTEADINESS OF LAMINAR SEPARATION BUBBLES

A. V. DOVGAL, *ITAM SB RAS, Russia*, V. V. KOZLOV, *ITAM SB RAS, Russia,* Wind-tunnel data on hydrodynamic instabilities associated with local regions of laminar boundary layer separation are reported. Even at low Reynolds numbers separation bubbles are prone to growth of velocity perturbations resulting in a nonstationary flow pattern. The latter is dominated by several instability features including the transition to turbulence in the separated shear layer and the large-scale unsteadiness of separation bubbles in the form of coherent vortices shedding from the region of reattachment. There are a number of indications that these phenomena may be quite different, that is, related to the convective instability of local mean-velocity profiles and to global dynamics of the entire separation bubble. Global modes of oscillations at laminar flow separation were found through stability analysis in a series of recent studies. The experiments we performed on this subject were as follows. Laminar separation bubbles behind 2D backward-facing steps on a plate surface were examined at low subsonic oncoming-flow velocities through hot-wire measurements. Several experimental regimes differing by the step height comparable with the boundary layer thickness were investigated. Under “quiet” free-stream conditions, the unstable flow in separation bubbles was obtained with transition to turbulence occurring well behind the region of reattachment. As a result, two scales of the natural separated-flow perturbations were distinguished. Those were high-frequency instability waves of the separated shear layer and low-frequency oscillations in the universal frequency range of vortex shedding. The latter originated irrespective of the shear-layer instability and were found as much different from the convective disturbances generated at the step by the oncoming-flow perturbations. To control the global separated-flow unsteadiness, active techniques were tried including continuous suction of the near-wall fluid and small-amplitude periodic forcing of the separation bubble. Both of them appeared as modifiers of the large-scale vortex motion.

T-3C-4. THE EXISTENCE OF A CRITICAL BLOCKAGE FOR CIRCULAR CYLINDERS UNDERGOING VIV AT LOW RE

T. K. PRASANTH, S. MITTAL, *Department of Aerospace Engineering, Indian Institute of Technology Kanpur, India,* Vortex-induced vibration (VIV) of a circular cylinder in the laminar regime has been studied numerically using a stabilized finite element method in two dimensions. The computations are carried out at various mass ratios ($1 \le m^* \le 100$) and blockages ($0.25\% \le B \le 12.5\%$). The effect of mass ratio and blockage on hysteresis phenomenon near the onset of synchronization has been investigated. It is found that for a given m*, hysteresis depends on blockage. The hysteresis loop width decreases with decrease in blockage at all mass ratios. For low mass ratios ($m^*<11$) the hysteresis loop width decreases with decrease in blockage and completely disappears at a *critical blockage*. The variation of this critical blockage with m* is found to be non-monotonic in nature. However for $m^*>11$, the response is hysteretic irrespective of the blockage. At higher blockage, large hysteresis loop width is observed. The hysteresis loop width decreases with decrease in blockage and attains a minimum value at very low blockage. There is a critical mass ratio ($m^*=10.11$) which divides the entire m* range into two. Below $m^*=10.11$ non-hysteretic response is observed at sufficiently low blockage. Above $m^*=10.11$ the response will always be hysteretic irrespective of the blockage. Hence the critical blockage is not defined for $m^*>10.11$. The variation of hysteresis loop width with blockage is found to be similar at various mass ratios for $m^*>10.11$. The hysteresis loop width for mass ratios, $m^*>10.11$ can be represented as a function of mass ratio and blockage. This enables us to predict the hysteresis loop width for an experiment once mass ratio and blockage are known. The various hysteresis loop width contours are plotted in the m* v/s blockage plane. The critical blockage curve ($\Delta Re=0$) divides the m* v/s blockage plane into two. Inside the curve, the response is non-hysteretic and outside the curve, it is hysteretic in nature. This clearly explains the discrepancy in the observation of hysteresis behavior by various researchers. This is the first time the discrepancy in the observation of hysteresis in VIV by various researchers has been explained based on m* and blockage. The hysteresis loop width reported at higher Re is found to match exactly with the value obtained from the present computations. This is despite the fact that most experiments have been conducted at higher Re, beyond the laminar flow regime. It appears that the effect of Re on the blockage v/s m* curve is not significant.

16:00 ~ 17:20 (Room 104)

Aerodynamics (II)

Session Chair : Dr. D. S. Lee, KARI/Korea

T-3D-1. EFFECTS OF JET BLOWING ON THE SIDE FORCE ON FOREBODIES WITH DIFFERENT CROSS SECTION

Youbing ZENG, Zhiyong LU, *Fluid Mechanic Institute, Beijing University of Aeronautics and Astronautics, China,* A flying wing is one of choices for the purpose of reducing Rader Cross Section in the next generation fighter aircraft. A jet blowing at the nose is one of the most popular methods to control the sideforce. The asymmetry of vortices over the forebody and their aerodynamic characters are changed by blowing. The influence of blowing on the side force and yawing moment depends on the cross section shape of the forebody. Three different section shapes of forebodies were chosen to be used in the force measurement experiment. Two blowing methods were adopted in the wind tunnel test which were the blowing normal to the surface through a hole and blowing tangential with the surface through a jet (circumferential pointing angle is able to change the blowing direction of the jet). In the case the maximum side force coefficient of normal blowing on the cone-cylinder is reduced by 43% from Cz=3.5 to 1.8 at incidence ranging from 20°to 65°. It is found that the change of the blowing momentum coefficient has a little influence on the side force coefficient on the cone-cylinder while using normal blowing. In the case of the tangential blowing, test result shows when the circumferential pointing angle of the nozzle is set at 330° with 0.03 momentum coefficient the maximum side force coefficient on the cone-cylinder is reduced from -3.6 to -2.5. And the reverse side force coefficient nearly disappears which is good for yaw control. The experiment of force measurement with the ellipstic section forebody shows when the circumferential pointing angle of the nozzle is set at 300° and 330°the side force coefficient is reduced from Cz=2.5 to 1.0. The experiment result with the chined forebody illustrates that the jet blowing would increase the side force coefficient on the chined forebody slightly. The pointing circumferential angle of 90° and 270° are the optimum blowing pointing position.

T-3D-2. INVESTIGATION OF FLOW FIELD AROUND BLUNT PROTRUSIONS AT SUPERSONIC SPEED

J. K. PRASAD, *Department of Space Engineering & Rocketry, B.I.T Mesra - Ranchi, India,* S. DAS, *Department of Space Engineering & Rocketry, B.I.T Mesra - Ranchi, India,* Many of the aerospace vehicles like rockets, missiles, aircraft, etc, have blunt protrusions projecting on the external surface due to various reasons. Blunt fins are also being adopted or thought to generate the possible control forces for future aerospace vehicles. At supersonic speed, the shock wave generated by the blunt protrusion, interacts with the approach boundary layer and leads to a complex flow